REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*

2. REPORT TYPE
Technical Papers

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER
1011

5e. TASK NUMBER
0062

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

8. PERFORMING ORGANIZATION REPORT

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
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5 Pollux Drive
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10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Leilani Richardson
Unclassified	Unclassified	Unclassified	A		19b. TELEPHONE NUMBER *(include area code)* (661) 275-5015

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

6 separate items are enclosed

[redacted]

10110062 FILE

MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO)

29 Mar 2001

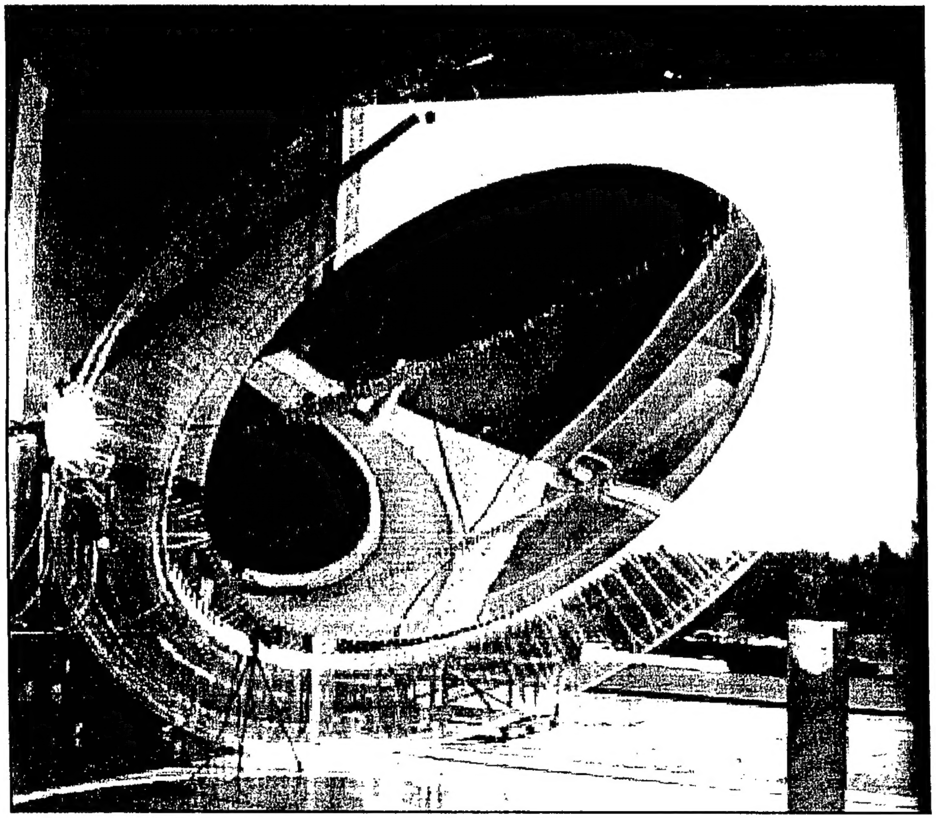
SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2001-071**
Holmes, Michael R., "~~Solar Thermal Propulsion IHPRPT Program" (VuGraphs~~)

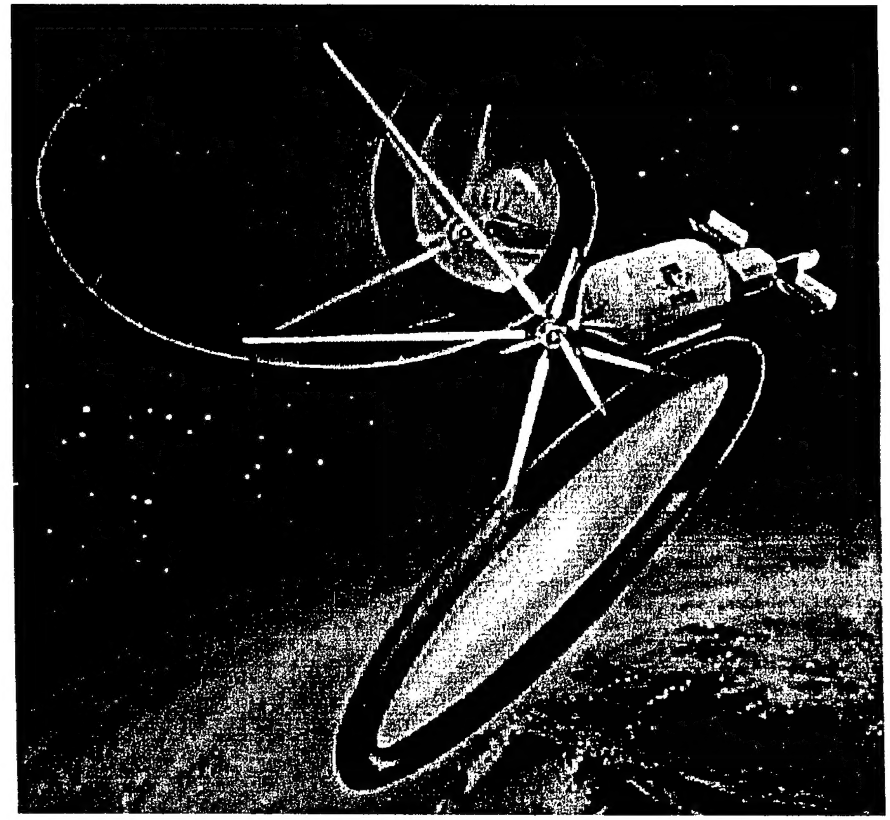
5615

12th Advance Propulsion Workshop
(Huntsville, AL, 2-6 Apr 2001) (Deadline: 02 Apr 2001)

(Statement A)

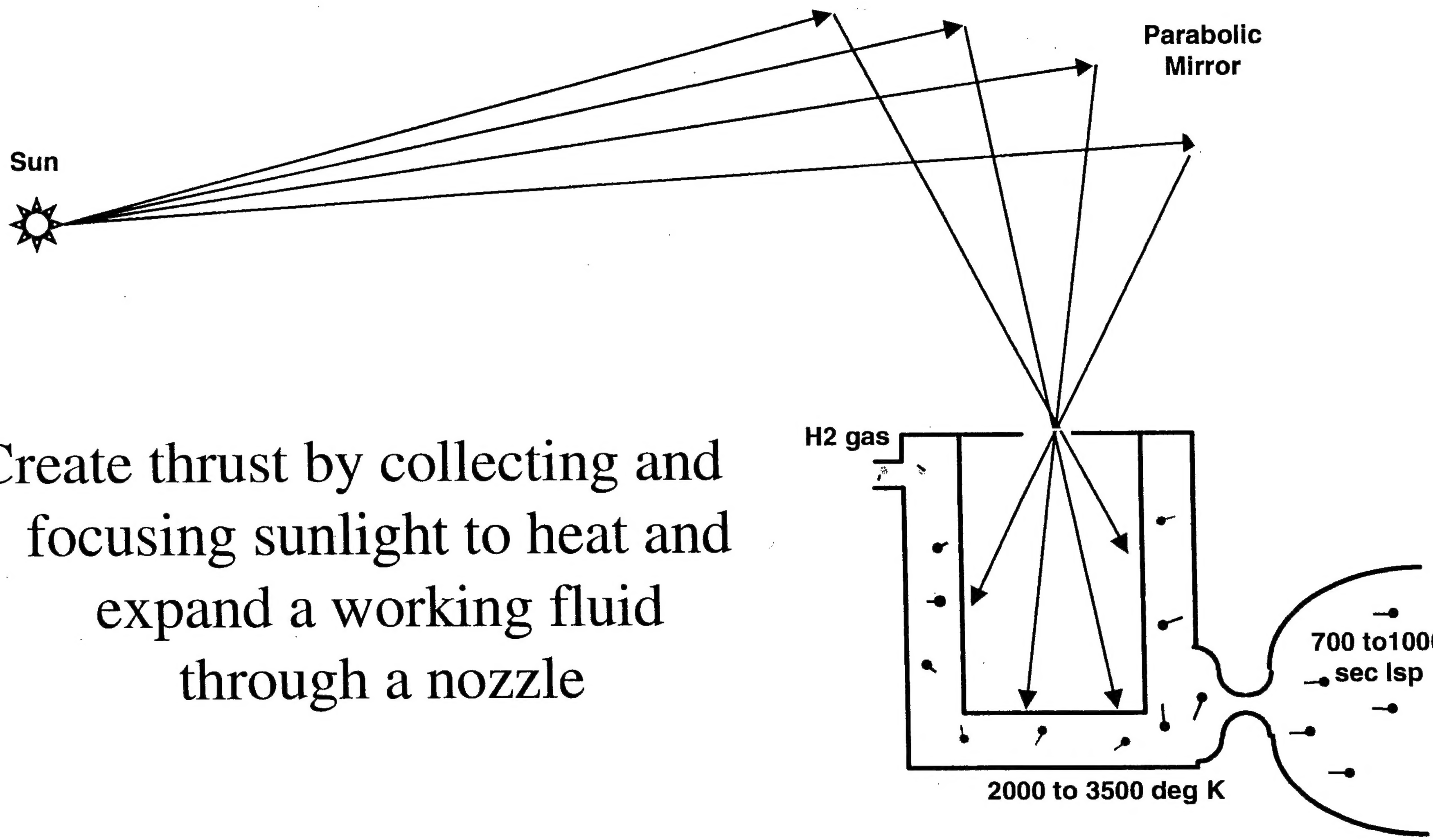
SOLAR ROCKET PROPULSION
Ground and Space Technology Demonstration





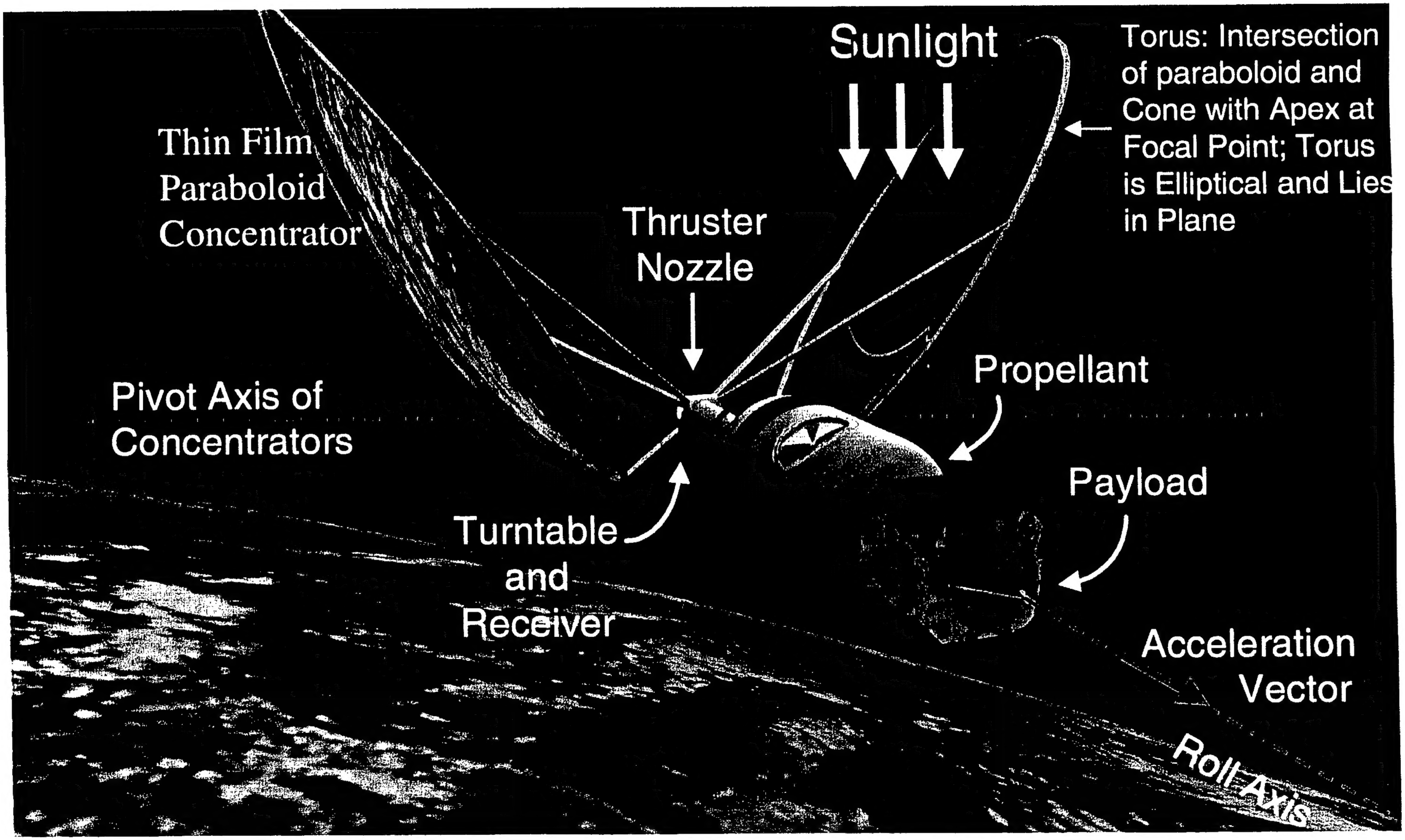
Dr. Michael Holmes, AFRL/PRSS

Solar Thermal Propulsion Concept



Create thrust by collecting and focusing sunlight to heat and expand a working fluid through a nozzle

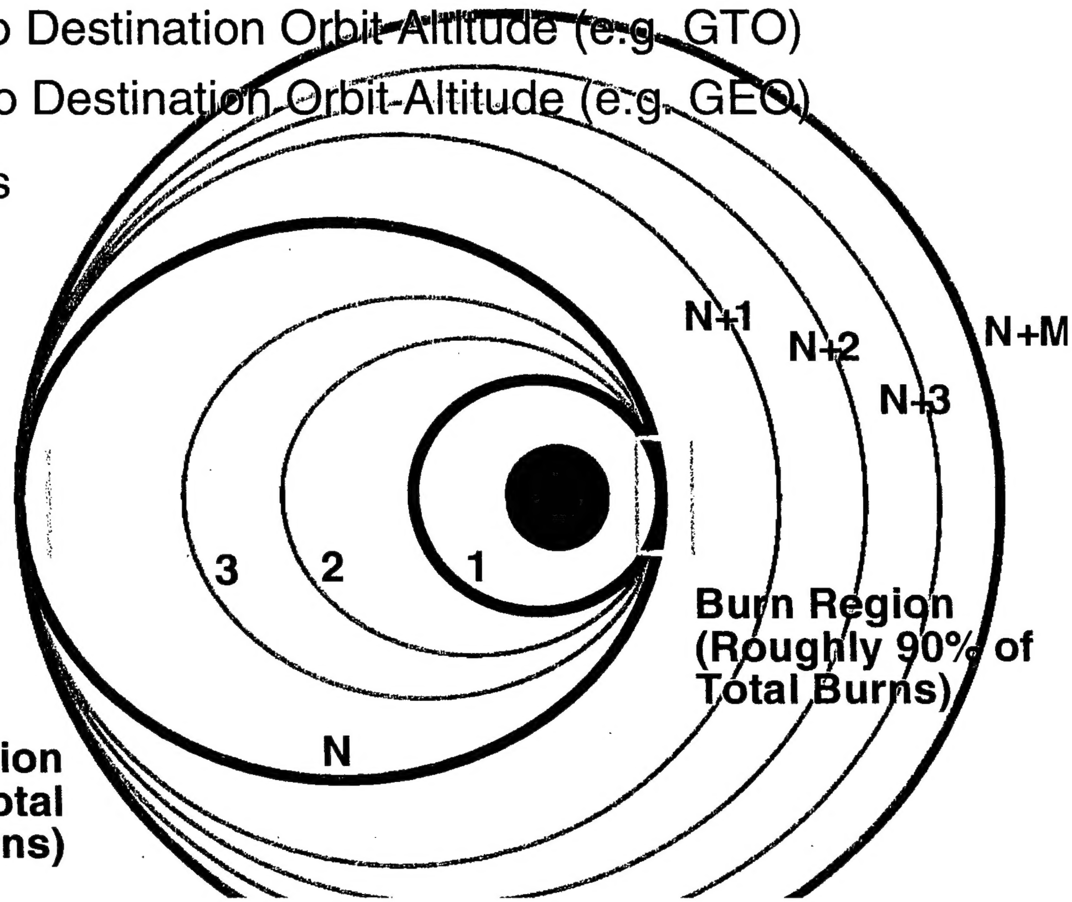
Solar-Thermal System Concept



Solar Thermal Propulsion
Orbit Transfer Scenario

- Maximum Delta V Thru Multi-Burn Transfer
- Solar Thermal OTV to LEO by Ground Launch
- N Perigee Burns to Raise Apogee to Destination Orbit-Altitude (e.g. GTO)
- M Apogee Burns to Raise Perigee to Destination Orbit-Altitude (e.g. GEO)

- Trip Time = Sum of N+M Orbit Periods
- Higher Thrust Reduces N+M
  - Requires More Power, or
  - Reduces Delta V
- Longer Burns Reduces N+M
  - Can Decrease Delta V by Gravity Losses
- N+M=2 for Chemical Thruster
- N+M~200 for Solar Propulsion



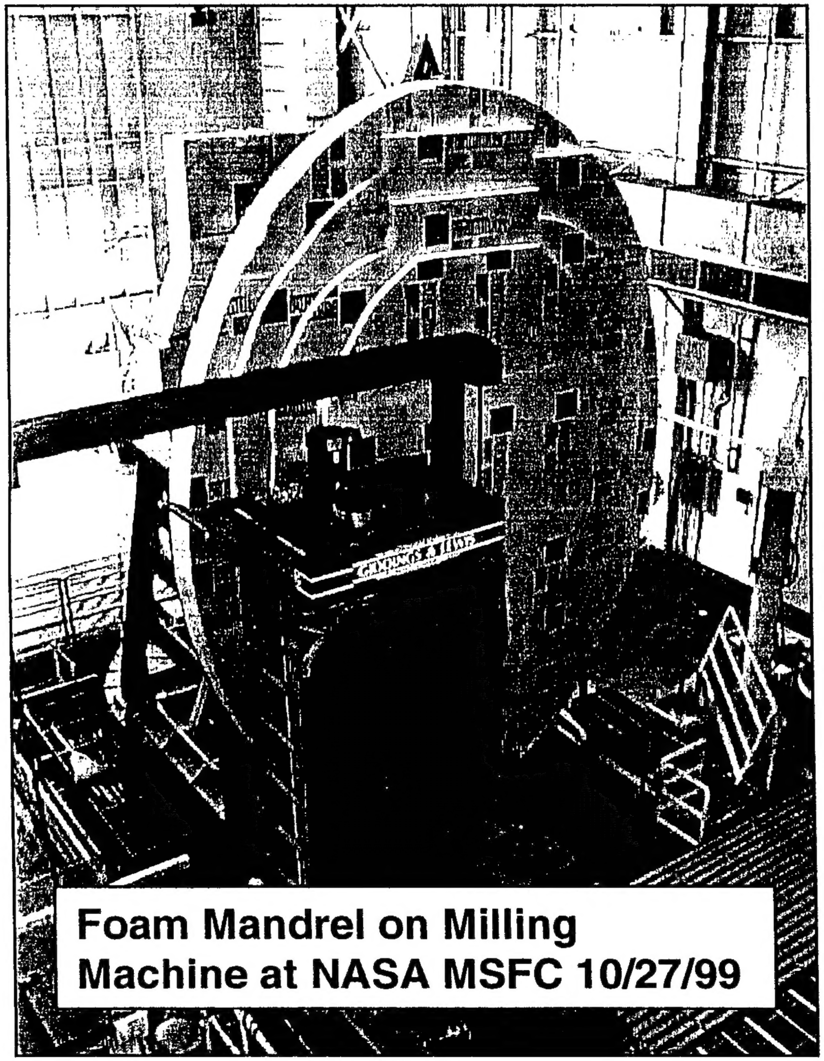
STP Doubles Payload in Reasonable Trip Time From LEO

Solar Propulsion
IHPRPT Goals

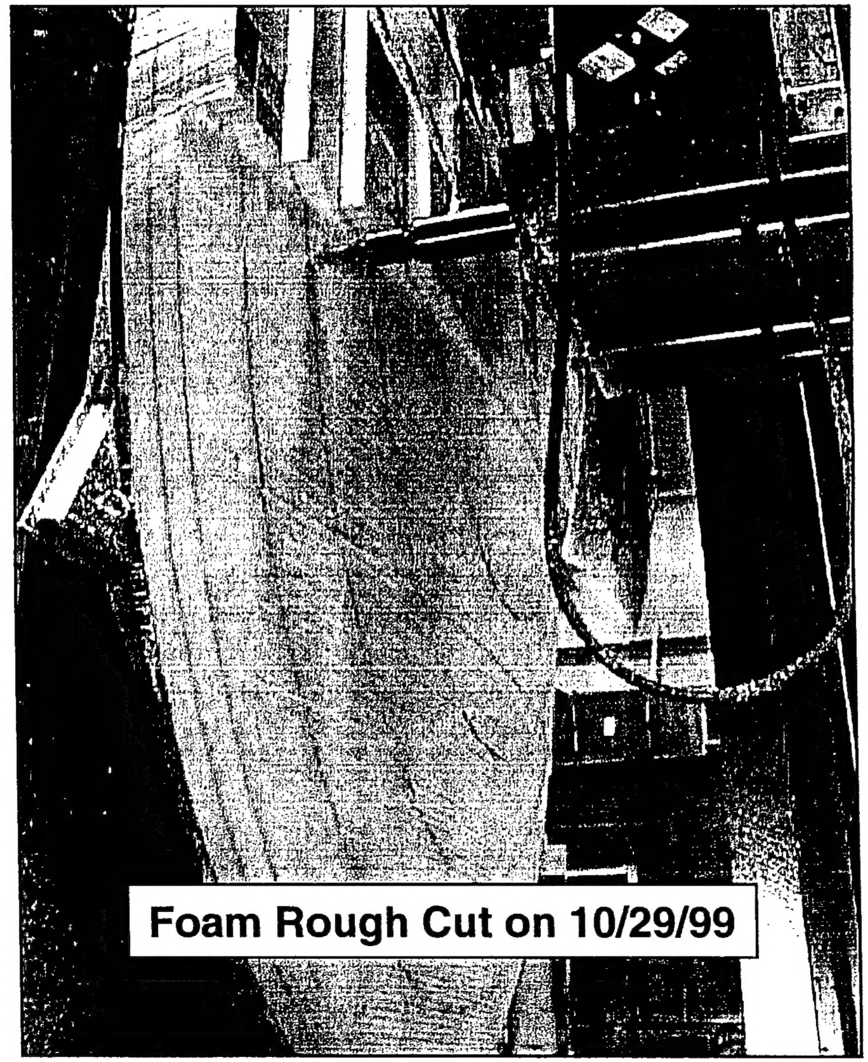
GOALS	BASELINE	PHASE I GOAL	PHASE II GOAL	PHASE III GOAL
Isp	720 sec	792 sec 10 %	828 sec 15 %	864 sec 20 %
Mass Fraction R_m	.66	.696 5%	.722 9%	.749 13%
Dry Mass Reduction		15%	25%	35%

Mission : LEO to GEO (250nm at 28deg) ~30day

Foam Mandrel 10/29/99



Foam Mandrel on Milling Machine at NASA MSFC 10/27/99

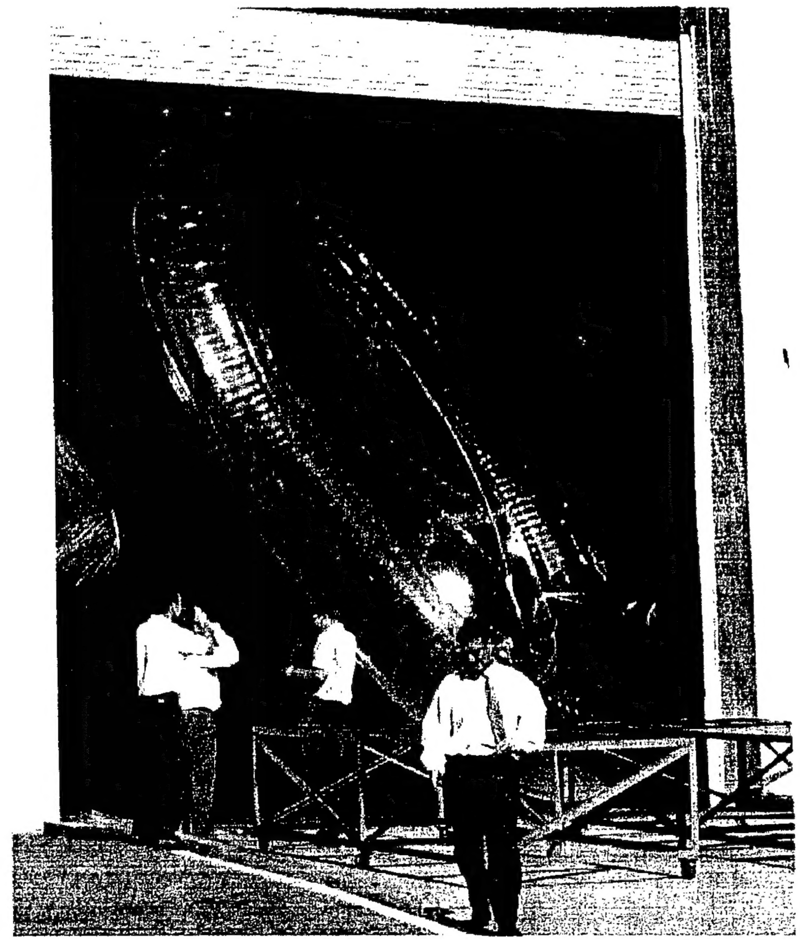


Foam Rough Cut on 10/29/99

Flight Scale Concentrator (FSC)

- FSC Mandrel Machined and Measured (Jan 00)
  - SRS Modeled and Generated CNC Machining Code
  - NASA MSFC Machined Mandrel
  - FSC-2 Using Foam Mandrel With Teflon Coating
- FSC-1 Fabricated (May 00)
- Method Developed to Deposit, Cure, and Release Film on Foam Mandrel
- FSC-2 (Optical Quality) Currently Being Fabricated

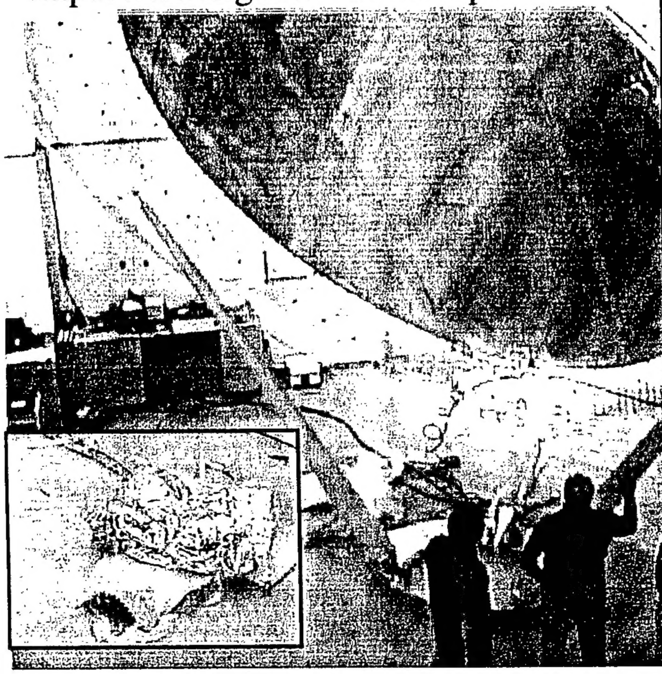
FSC-1



Concentrator Deployment Repeatability Demonstrated in IT-4 &5

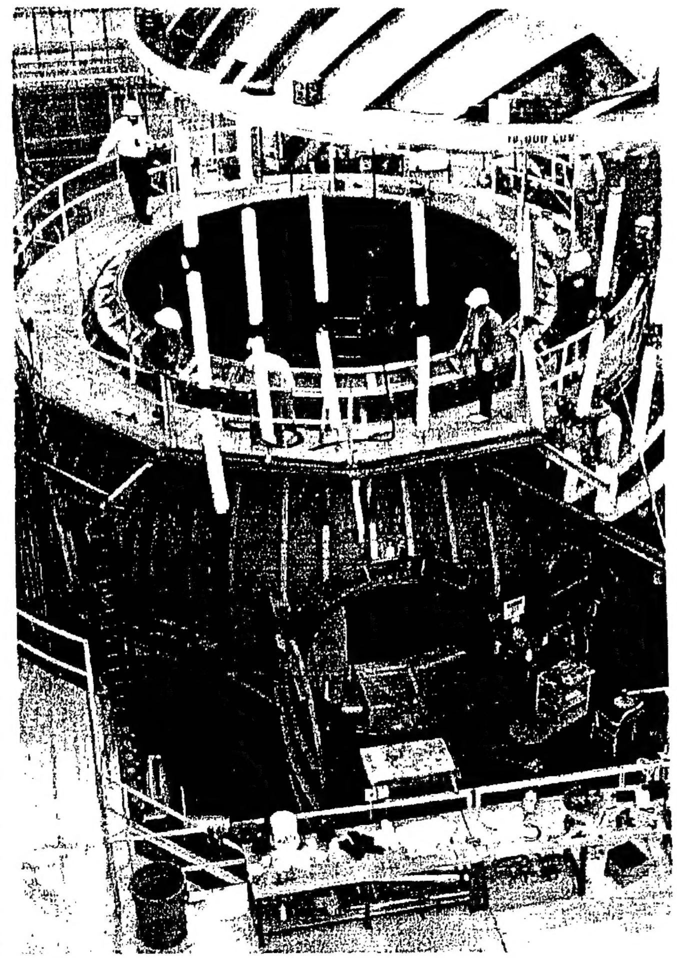
- Deployment fold pattern / packaging concept verified
- Measured< 0.5 inches variation in global geometry over 4 deployments
- No difference in global geometry observed between ambient pressure and vacuum (10^{-6} torr) deployment

Deployment Video:
http://www.stg.srs.com/aerospace.htm



Flight Scale Concentrator Ambient Deployment

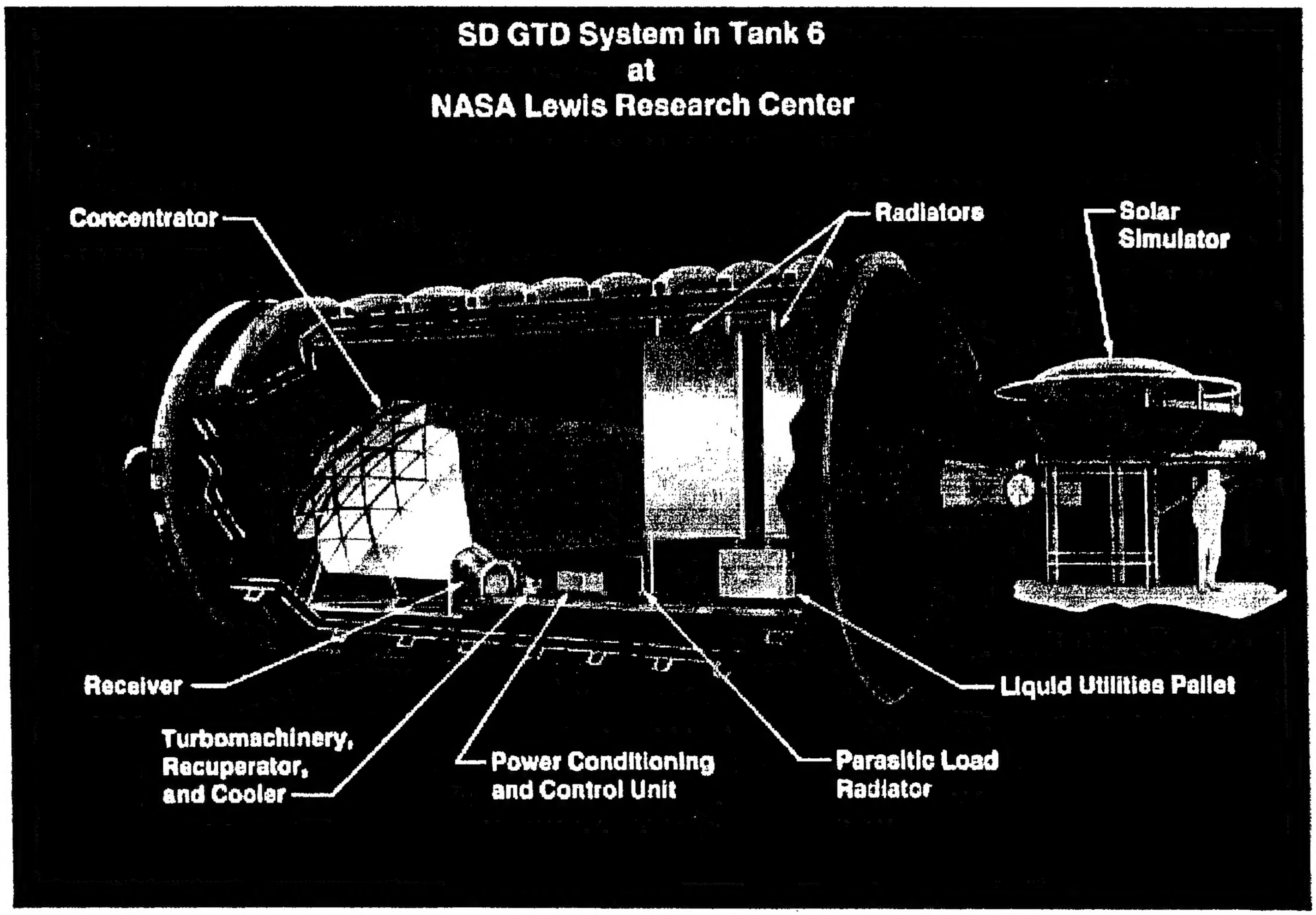
Flight Scale Concentrator inside SPEF Chamber



AFRL's Space Environmental Test Facility

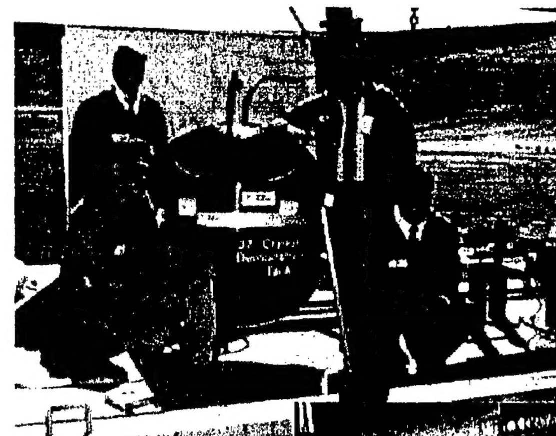
TA-1 Tank 6 Apparatus Thermal Vacuum Testing

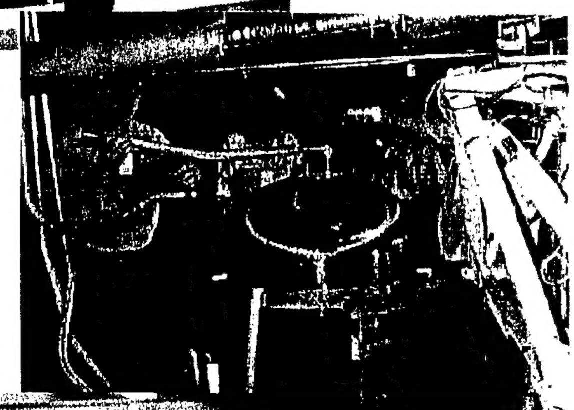
- NASA GRC Tank 6 Simulates Space Thermal Environment
- Concentrator Shape and Position Verified under Mission Eclipse Cycling



Propellant Management System Experiment

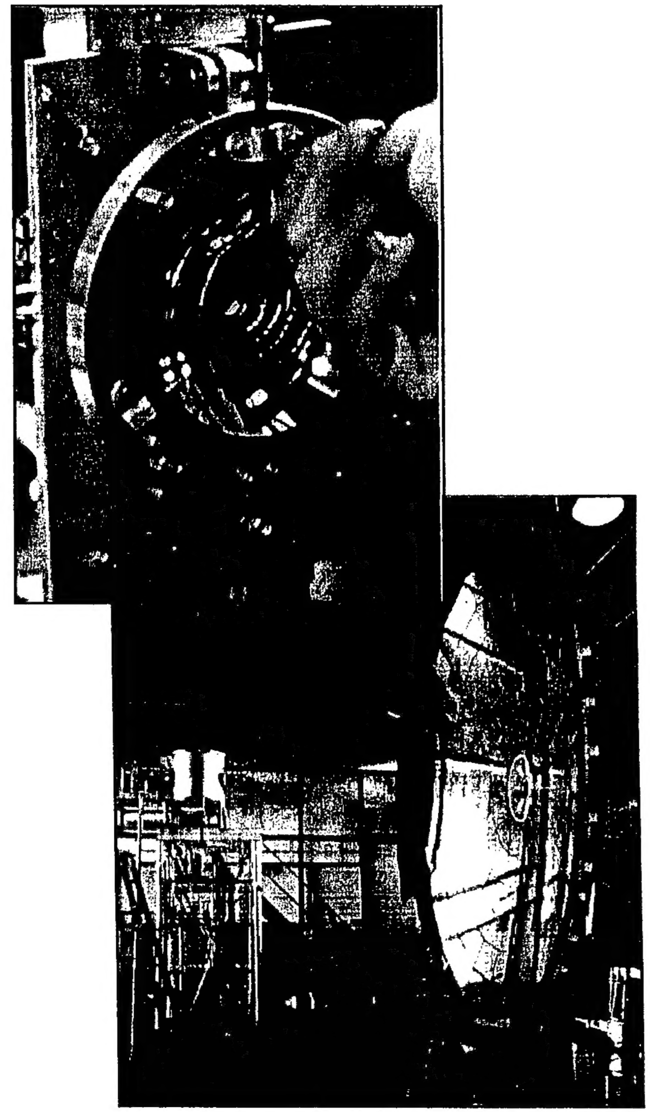
- New Approach to Cryogenic Propellant Management
  - Control Tank Pressure by,
    - Remove Vapor -> Lower Pressure
    - Remove Liquid -> Raise Pressure
    - Acceleration Pulls Liquid to "Bottom" of Tank
  - Advantages
    - Large Heater Eliminated
    - Thermodynamic Vent System (TVS) Eliminated
    - Mixer Eliminated
    - Simplified Control Software
    - Lower Pressure Tank -> Lower Weight
  - Preliminary Results Very Good
  - SRS and MSFC have Models and will Compare to Data
- Thiokol Composite Tank Reduces Tank Fraction





Solar-Thermal Propulsion
Thiokol/SRS Thruster Design

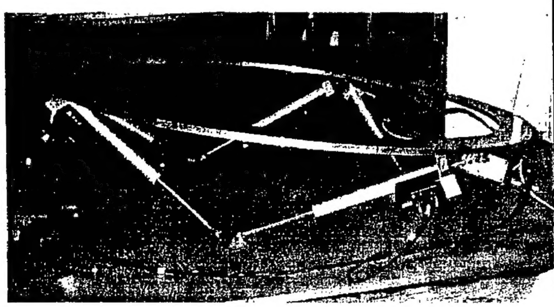
- Well Tuned to Input Light Distribution
- Beam Fractionating
  - Highest Intensity at Hottest Propellant
  - Pointing Error Tolerant
  - Lowest Intensity at Coolest Propellant
- Optical Blackbody Cavity
  - Minimize Insulation
  - Secondary Mirror Cooled by Incoming Propellant
- Capable of Meeting Phase II IHPRPT Goals
- Technologies Extensible to Phase III
- Proven in Short Duration Testing (<10 hours)
- Working on 3-D Model



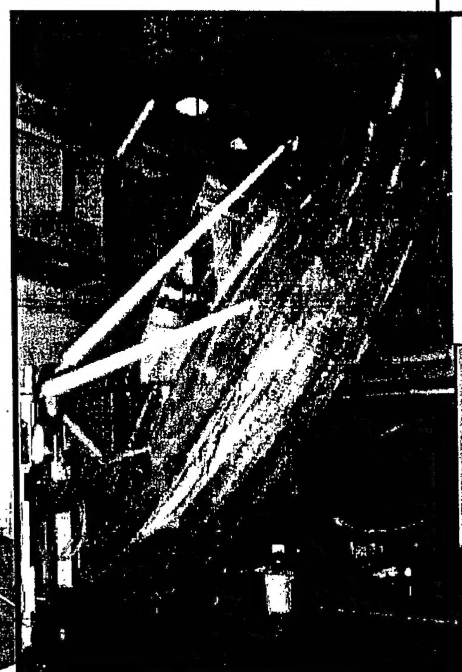
First Ever Integrated Test Of Solar Thermal Propulsion System This Summer

- Concentrator will track sun
- Matches flux profile but not power of space system
- Thruster in vacuum chamber
- 792 sec Isp will be shown by analytical correction of:
  - 25% atmospheric loss
  - 10% window loss

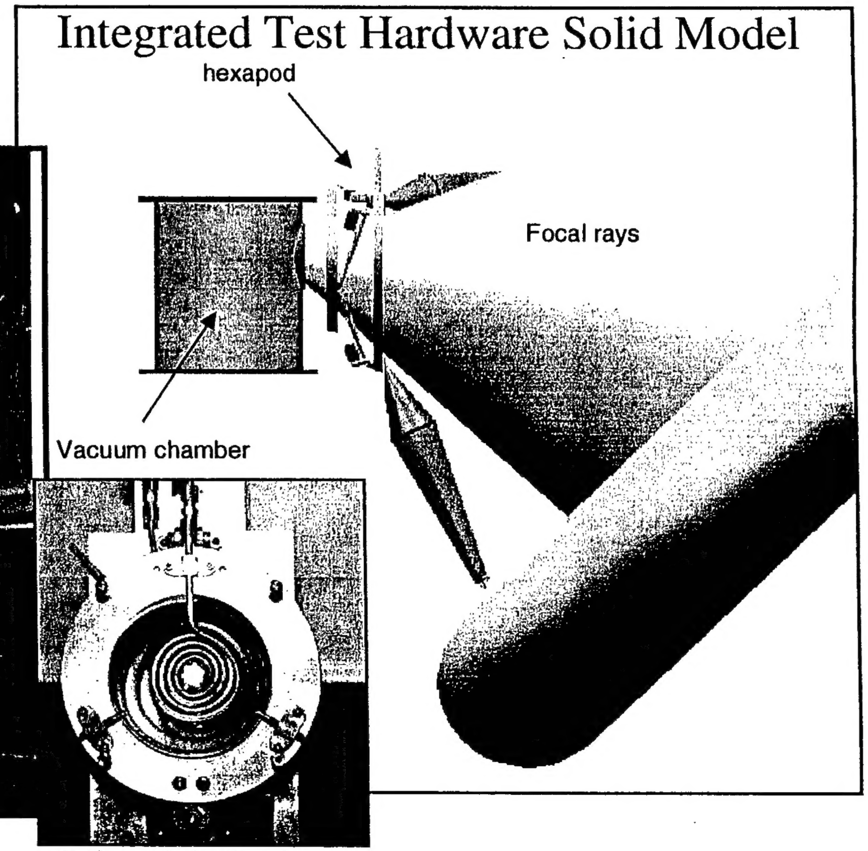
Hexapod Focusing Model



Hexapod Focusing Test Bed



Concentrator Assembly



Direct Gain Engine